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A Study on the Impact of E-Commerce on the Innovation of Online Transaction Models in Real Estate Markets

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Abstract With the rapid development of the Internet and e-commerce technology, the traditional real estate transaction mode is experiencing unprecedented changes. This study explores the impact of e-commerce development on the innovation of online transaction mode in real estate market through fuzzy hierarchical analysis and multiple regression analysis. It is found that the development of e-commerce significantly promotes the innovation of real estate transaction mode, and this effect shows a significant positive effect at different innovation levels. Specifically, for every 1% increase in the level of e-commerce development, the level of real estate transaction model innovation increases by 0.122%. In addition, factors such as the level of economic development, per capita income and industrial structure also play a positive role in promoting real estate transaction model innovation. By analyzing the data of a region from 2015-2024, the results show that the online transaction mode innovation in the real estate market has shown a rising trend year by year, indicating that the extensive application of e-commerce in this field has had a far-reaching impact. The conclusion further emphasizes the importance of the integration of e-commerce and the real estate market, and provides recommendations for real estate companies to strengthen e-commerce.

Index Terms e-commerce, real estate market, transaction mode innovation, fuzzy hierarchical analysis, multiple regression, economic efficiency

I. Introduction

With the rapid development and popularization of the Internet, e-commerce has become an important part of the modern economy [1]. The rise of e-commerce has not only changed the pattern of traditional retail industry, but also had a profound impact on the innovation of online transaction mode in real estate market [2], [3].

First, the rise of e-commerce has impacted the traditional real estate sales model [4]. While the traditional sales model usually relies on physical sales offices and salespersons, e-commerce provides the convenience of searching, browsing and purchasing online [5], [6]. Homebuyers can learn more information about property listings, compare and filter information through the Internet platform, and reduce their reliance on salespersons [7], [8]. This poses new challenges to traditional sales channels and salespersons, requiring them to change their thinking and improve their service level to adapt to the new market environment [9], [10].

Secondly, with the popularization of e-commerce, more and more real estate enterprises have begun to conduct online sales through Internet platforms [11]. The advantage of online sales is that it can break through geographical restrictions and involve more potential home buyers [12]. Online sales can also provide a more convenient and faster home-buying experience, reducing the time and energy costs of home buyers [13], [14]. The rise of online sales enables real estate companies to better reach their target customer groups and improve sales efficiency [15], [16].

In addition, the rise of e-commerce has brought new opportunities and innovations to real estate marketing [17]. Real estate companies can conduct accurate positioning and marketing through the Internet platform, providing personalized recommendations and services based on users' search and browsing behavior [18], [19]. E-commerce can also help companies better understand user needs and provide more accurate products and services through data analysis and artificial intelligence technologies [20]-[22]. Through cooperation with other industries, real estate companies can also provide one-stop home-buying solutions through e-commerce platforms to enhance user experience [23], [24].

With the continuous progress of science and technology and the popularization of the Internet, the mode of traditional industries is constantly being innovated and changed. The real estate industry, as one of the basic industries related to people's livelihood, has long been plagued by problems such as information asymmetry and

inefficient transactions. Especially in the context of increasingly diversified market demand and globalization, the real estate market is in dire need of finding a new model that can enhance efficiency, reduce intermediaries and increase transparency. The emergence of e-commerce has brought new development opportunities for real estate transactions, which breaks the limitations of the traditional transaction model that must rely on physical platforms and face-to-face contact, and provides strong support for the innovation of the real estate market through the release of information, transactions and communication through online platforms.

Driven by e-commerce, the real estate transaction model has gradually shifted from traditional offline transactions to online transactions, a shift that not only improves the efficiency of market transactions, but also provides consumers with more convenient choices. Especially in the process that homebuyers can learn about property listings, make online selections and make inquiries through the Internet, real estate developers have achieved wider dissemination of information and precise target market targeting through e-commerce platforms. However, this shift is not without challenges. The special nature of real estate products requires that the online transaction mode must be combined with offline viewing to ensure the security and authenticity of the transaction. Therefore, how to promote the innovation of online transaction mode under the premise of ensuring transaction security has become an important issue for the real estate industry.

This study explores how the development of e-commerce promotes the innovation of online transaction mode in the real estate market through data analysis. Through the collection and analysis of relevant data, the study will reveal the role of e-commerce in improving transaction efficiency and optimizing resource allocation in the real estate market, and provide practical guidance for real estate enterprises in the process of digital transformation. Through this study, it is expected to provide useful theoretical references and policy recommendations for the real estate industry, and to promote a healthier and more sustainable development of the real estate market.

II. Application of e-commerce in real estate market transactions

With the rapid development of computer and Internet technology, e-commerce has also been developed, making great contributions in various fields, especially with the organic combination of real estate transactions, not only changed the traditional mode of real estate transactions, but also solved the problems that existed between the government's macro-control, and promoted the stable development of the real estate industry.

II. A.Electronic information dissemination

As the traditional real estate transactions have always existed the problem of information inequality, two e-commerce and real estate transactions for the organic combination of these problems can be avoided. Real estate developers can change the traditional way of information dissemination, publicity through the network, the establishment of its own characteristics of the website, which not only can make the transaction information coverage is more extensive, but also can make the information dissemination more quickly.

II. B.Leading to enhanced e-commerce

At present, most of the real estate industry is still transacted through traditional means of transaction. Therefore, it is necessary to actively guide the real estate business to strengthen the construction of e-commerce, to provide personalized services for homebuyers, improve transaction efficiency. In turn, this will promote the improvement of the economic efficiency of real estate enterprises. In addition, the enterprise intranet is also a part of e-commerce, through the establishment and improvement of the enterprise intranet, can realize the transparency of information, openness, and promote the optimization of the enterprise business structure, and then enhance the visibility of the enterprise, set up a good image of the enterprise, and ultimately promote the expansion of the enterprise's business volume and improve economic efficiency.

II. C.Establishment of an online trading model

Due to the traditional real estate transactions there are many shortcomings and defects, in particular, the viewing and selection process is very cumbersome, the healthy development of the real estate industry to cause certain obstacles, but due to the special nature of real estate products, the online viewing to ensure that the authenticity of its real estate, only to the site of the real environment in order to understand the specific situation of the house. Therefore, by establishing a combination of online selection and offline viewing mode, double guarantee, not only can save time, optimize the allocation of resources, but also to ensure that the interests of the buyers, to avoid the occurrence of problems such as mismatch of information with real estate developers.

II. D.Enhancement of network security

Since the network has certain risks, in order to ensure information security, real estate developers should strengthen the information security construction of the network to prevent the leakage of confidential information

involved in the transaction process, thus causing certain economic losses to both parties. In addition, strengthening the construction of network information security can not only ensure information security, but also guarantee the stability and reliability of network system operation.

III. Research hypothesis and methodology

In the context of “Internet + e-commerce”, the popularity of e-commerce has reshaped the traditional real estate market transactions, this study focuses on the impact of e-commerce on the innovation of online transaction mode in the real estate market.

III. A. Research hypotheses

According to the analysis in the previous section, there are various roles of e-commerce in real estate market transactions that can promote the economic efficiency of the real estate market. Therefore, this paper proposes the following hypotheses:

H1: The development of e-commerce can stimulate the innovation of online transaction mode in real estate market.

H2: The development of e-commerce can push the innovation of online transaction mode in real estate market to a higher level.

III. B. Research methodology

This paper constructs the evaluation index system of e-commerce development level and real estate online transaction mode innovation, uses the fuzzy hierarchical analysis method to evaluate them, and then uses the multiple regression method to analyze the relationship between them.

III. B. 1) Fuzzy hierarchical analytical models

The Analytic Hierarchy Process (AHP) is a multi-objective decision analysis method that makes it easy to make decisions for some of the more complex and fuzzy decision problems. A hierarchical structure is established for the top level (objective level), the middle level (criterion level or indicator level), and the bottom level (program level or decision level) that constitute the assessment problem. The key to hierarchical analysis is to establish a judgment matrix, and whether the judgment matrix is scientific and reasonable will directly affect the practical application of hierarchical analysis. Hierarchical analysis method often appears to be very difficult to test whether the established judgment matrix has consistency, which seriously affects the follow-up work. For this reason, this paper introduces the theoretical knowledge of fuzzy mathematics, and in this way introduces the concept of fuzzy consistency matrix, and then carries out fuzzy comprehensive judgment. Moreover, the fuzzy hierarchical analysis method fully absorbs and uses the characteristics of behavioral science to quantify the decision maker's empirical judgment, which is more suitable for the case where the structure of the objectives (factors) is complex and lacks the necessary data. In system science, fuzzy hierarchical analysis (FAHP) is one of the more commonly used system analysis methods.

Whether the constructed fuzzy judgment matrix meets the consistency test is a key step whether the fuzzy hierarchical analysis model can go on. When the initially constructed fuzzy judgment matrix does not pass the consistency test, the fuzzy judgment matrix needs to be scientifically and reasonably adjusted to make it meet the consistency. Of course, it is not excluded that in the process of adjusting the fuzzy judgment matrix, it is necessary to go through a number of adjustments, testing, re-adjustment, re-testing cycle until the fuzzy judgment matrix meets the consistency test. When the fuzzy judgment matrix does not meet the consistency test, the Lagrange least squares method can be used to quickly and effectively adjust the fuzzy judgment matrix to obtain the required weight vector, at this time the problem is transformed into the following linear constraint planning problem:

$$\begin{cases} \min z = \sum_{i=1}^{n}\sum_{j=1}^{n}\left[0.5 + a(\omega_i - \omega_j) - r_{ij}\right]^2 \\ s.t.\sum_{i=1}^{n}\omega_i = 1, \omega_i \geq 0, (1 \leq i \leq n) \end{cases} \tag{1}$$

By the Lagrange least squares method, the linearly constrained planning problem for (tl) can be equated to the following unconstrained planning problem:

$$\min L(\omega,\lambda)=\sum_{i=1}^{n}\sum_{j=1}^{n}\left[0.5+a(\omega_i-\omega_j)-r_{ij}\right]^2+2\lambda\left(\sum_{i=1}^{n}\omega_i-1\right) \tag{2}$$

where λ is the Laggrange multiplication operator.

In the above equation, $L(\omega,\lambda)$ takes the partial derivatives of $o_i(i=1,2,\cdots,n)$, respectively, and makes the resulting polynomial zero, which in turn yields a n-dimensional system of linear equations:

$$a\sum_{j=1}^{n}\left[0.5+a(\omega_i-\omega_j)-r_{ij}\right]-a\sum_{k=1}^{n}\left[0.5+a(\omega_k-\omega_i-r_{ki})\right]+\lambda=0 \tag{3}$$

where $i=1,2,...,n$.

The problem (t3) can be transformed into (t4):

$$\sum_{j=1}^{n}2a^2(\omega_i-\omega_j)+a(r_{ji}-r_{ij})+\lambda=0 \tag{4}$$

where $i=1,2,...,n$

The weighting condition $\sum_{i=1}^{n}\omega_i=1,\omega_i\geq 0,(1\leq i\leq n)$ and problem (t4) actually form a system of linear equations with $n+1$ unknowns $(\omega_1,\omega_2,\omega_3,\cdots,\omega_n,\lambda)$ as follows:

$$\begin{aligned}
&2a^2(n-1)\omega_1-2a^2\omega_2-2a^2\omega_3-...-2a^2\omega_n+\lambda=a\sum_{j=1}^{n}(r_{lj}-r_{jl})\\
&-2a^2\omega_1-2a^2(n-1)\omega_2-2a^2\omega_3-2a^2\omega_4-...-2a^2\omega_n+\lambda=a\sum_{j=1}^{n}(r_{2j}-r_{j2})\\
&.....\\
&-2a^2\omega_1-2a^2(n-1)\omega_2-2a^2\omega_3-...-2a^2(n-1)\omega_n+\lambda=a\sum_{j=1}^{n}(r_{nj}-r_{jn})\\
&.....\\
&\sum_{i=1}^{n}\omega_i=1,\omega_i\geq 0,(1\leq i\leq n)
\end{aligned} \tag{5}$$

By solving this system of linear equations the required weight vector $\omega=(\omega_1,\omega_2,\omega_3...,\omega_n)^T$ can be obtained.

Before applying the fuzzy hierarchical analysis model, the first step is to deconstruct the complex problem to be studied, analyze the composition of the complex problem in depth, and then decompose it into different constituent factors, then establish a hierarchical structure in accordance with the highest level (the goal level), the intermediate level (the criterion level or index level), and the lowest level (the program level or decision level), and then rate the importance of the constituent factors of the levels, and finally make an overall assessment by combining the degree of importance of each factor with each other. Finally, the overall assessment is made by combining the degree of importance of the factors in relation to each other.

III. B. 2) Modeling of multiple regression methods

The method of regression analysis is a favorable method of expressing the degree of closeness to each other and building a statistical model based on this closeness, and further making predictions about the state of his structure and about the model, which is based on a large number of experiments and observations of objective things.

In multiple regression analysis, if there is a correlation between variable $x_1,x_2,\cdots,x_p$ and random variable y, this further suggests that when $x_1,x_2,\cdots,x_p$ is a fixed value, accordingly y will have a probability distribution to match it. The probability model between the correlated variable $x_1,x_2,\cdots,x_p$ and the random variable y is, the

$$y=f(x_1,x_2,\cdots,x_p)+\varepsilon \tag{6}$$

where the random variable y is the dependent variable; $x_1, x_2, \cdots, x_p$ is the independent variable; $f(x_1, x_2, \cdots, x_p)$ can be called a deterministic relationship of the general variable $x_1, x_2, \cdots, x_p$; and ε is the random error.

If the regression function is linear in the probabilistic model, i.e., there is that

$$y = \beta_0 + \beta_1 x_1 + \cdots + \beta_p x_p + \varepsilon \tag{7}$$

where $\beta_0, \beta_1, \beta_2 \cdots, \beta_p$ is called the $p+1$ unknown parameter, β_0 is the regression constant, $\beta_1, \beta_2 \cdots, \beta_p$ is the regression coefficient, y is the explanatory (dependent) variable, and $x_1, x_2, \cdots, x_p$ can also be referred to as the p independent variable that can be accurately measured. $p = 1$, is a univariate linear regression model. $p \geq 2$, then it is called a multiple linear regression model with random errors ε.

If $(x_{i1}, x_{i2}, \cdots, x_{ip}; y_i), i = 1, 2, \cdots, n$ is a set of observations for a variable $(x_1, x_2, \cdots, x_p; y)$, then the linear regression model is.

$$y = f(x_1, x_2, \cdots, x_p), i = 1, 2, \cdots, n \tag{8}$$

On the one hand, the very widely used is the regression model; on the other hand, if you want to get more in-depth and accurate results, under the conditions of linear regression model, according to the actual needs of the problem that does not have a linear relationship is converted into a linear regression model can be used to solve the research problem. Therefore, in the linear regression model is very important in the theoretical results and practical applications.

In regression analysis, multiple linear regression model is both simple and widely used. Here in this paper, the amount of real estate transaction model innovation is denoted as y, the i nd unit of real estate transaction model innovation is denoted as y_i, and the level of e-commerce is denoted as $(x_1, x_2, \cdots x_n)$. The general form of the model is.

$$y_i = \beta_0 + \beta_1 x_1 + \cdots + \beta_n x_n + \varepsilon \tag{9}$$

The matrix is of the form that

$$Y = X\beta + \varepsilon, \varepsilon \square N(0, \sigma^2 I_n) \tag{10}$$

$$X = \begin{bmatrix} 1 & x_{11} & x_{12} & \cdots & x_{1p} \\ 1 & x_{21} & x_{22} & \cdots & x_{2p} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ 1 & x_{n1} & x_{n2} & \cdots & x_{np} \end{bmatrix}, Y = \begin{bmatrix} y_1 \\ y_2 \\ \cdots \\ y_n \end{bmatrix}, \beta = \begin{bmatrix} \beta_1 \\ \beta_2 \\ \cdots \\ \beta_n \end{bmatrix}, \varepsilon = \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \cdots \\ \varepsilon_n \end{bmatrix} \tag{11}$$

The parameters to be estimated are $\beta_{(p+1)\times 1}$ and σ^2, $Y_{n\times 1}$ is the observation vector, $X_{n\times(p+1)}$ is the known matrix, and $\varepsilon_{n\times 1}$ is the random error vector.

If it is in matrix form, the dependent variable of the multiple linear regression model obeys a distribution of.

$$Y \square N(X\beta, \sigma^2 I_n) \tag{12}$$

So the likelihood estimation results in:

$$\begin{aligned} L(\beta, \sigma \mid Y, X.) &= \left(\frac{1}{2\pi\sigma^2}\right)^{\frac{n}{2}} e^{-\frac{1}{2\sigma^2}(Y - X\beta)^T (Y - X\beta)} \\ &= \left(\frac{1}{2\pi\sigma^2}\right)^{\frac{n}{2}} e^{-\frac{1}{2\sigma^2}[(Y - X\hat{\beta})^T (Y - X\hat{\beta}) + (\beta - \hat{\beta})^T X^T X (\beta - \hat{\beta})]} \\ &= \left(\frac{1}{2\pi\sigma^2}\right)^{\frac{n}{2}} e^{-\frac{1}{2\sigma^2}[aS_n^2 + (\beta - \hat{\beta})^T X^T X (\beta - \hat{\beta})]} \end{aligned} \tag{13}$$

$\hat{\beta} = (X^T X)^{-1} X^T Y, a = n - p - 1, \sigma^2 = S_n^2 = \frac{1}{a}(Y - X\hat{\beta})^T (Y - X\hat{\beta})$ of them.

IV. Empirical analysis

IV. A. E-commerce level measurement

IV. A. 1) E-commerce level indicator weights

The premise of measuring the level of e-commerce development needs to construct the evaluation index system, this paper in line with the principle of objectivity and data availability, selected three primary indicators, eight secondary indicators to represent the level of e-commerce development of the index system, and then use the hierarchical analysis method to assess the weight of each indicator. The indicators and weight coefficients of e-commerce development level indicator system are shown in Table 1. In the development process of e-commerce, the support index of the first-level indicators contributes the most to the development level of e-commerce, accounting for 57.8%. At the end of the list is the scale index with 14.8%. Among the secondary indicators, the Internet penetration rate has the largest weight, accounting for 17.7%, which is because the Internet penetration rate involves the expansion of the scale of Internet residents, in the past few years, the network coverage project has been deepening, the general public gradually keep pace with the Internet era and enjoy the convenience brought by online shopping, the higher the Internet penetration rate, the larger the scale of Internet residents, and the more the Internet can be used to shop on the e-commerce platform. The higher the Internet penetration rate and the larger the size of Internet users, the more residents can shop on e-commerce platforms through the Internet.

Table 1: Evaluation index and weight coefficient of the development level of e-commerce

Primary indicator	Weight	Secondary indicator	Weight
Support index	0.578	Internet penetration	0.177
		Internet broadband access port number	0.134
		Mobile phone penetration	0.158
		Domain number	0.109
Scale index	0.148	E-commerce transaction amount	0.079
		Express quantity	0.069
Permeability index	0.274	The average salary of an operator	0.122
		The number of enterprises with e-commerce transactions	0.152

IV. A. 2) E-commerce level assessment

Combining the weight values of the indicators at all levels in Table 1, the level of e-commerce development of a region in 2015-2024 is evaluated, and the comprehensive score of the level of e-commerce development of the region in 2015-2024 is calculated using fuzzy hierarchical analysis. The e-commerce index values measured in this paper for the past years are shown in Figure 1.The e-commerce index has been increasing from 2015 to mid-2024, growing from 0.185 to 0.597, with the growth rate varying from year to year. Overall, the level of e-commerce development in the region is good, showing the important position and great potential of the industry in the region's economy.

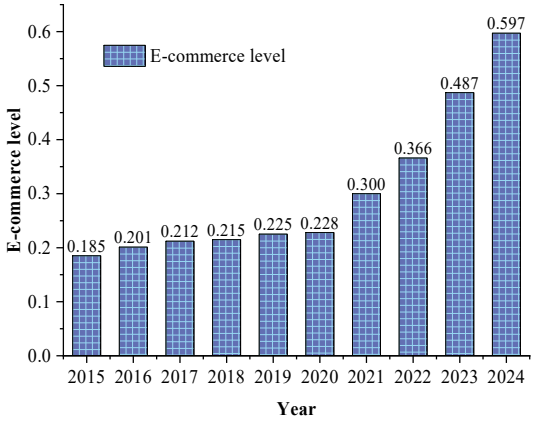

Figure 1: Assessment of e-commerce level

IV. B. Measuring Innovation in Real Estate Transaction Models

The index system of comprehensive evaluation of online transaction mode innovation in real estate market was established through expert scoring method, and the online transaction mode innovation in real estate market was evaluated through the combination of hierarchical analysis method and fuzzy comprehensive evaluation method.

IV. B. 1) Indicator weights

From the six dimensions of e-commerce website frontend, website traffic, website promotion, website backend, advertising effect and transaction results, 12 secondary indicators are subdivided to construct the evaluation index system. After calculation and collation, the weights of the indicators of the comprehensive evaluation system of online transaction mode innovation in real estate market are shown in Table 2. The weight values of website frontend, website traffic, website promotion, website backend, advertising effect and transaction result are 0.152, 0.161, 0.156, 0.095, 0.197, 0.239, respectively, of which advertising effect and transaction result have the greatest influence on the innovation of online transaction mode in real estate market. Among the secondary indicators, the total transaction value, average page views and advertisement conversion rate have the largest indicator weights, which are all greater than 0.110.

Table 2: The index weight of the innovation of real estate trading mode

Primary indicator	Weight	Secondary indicator	Weight
Website front desk	0.152	Page layout	0.105
		Retrieval function	0.047
Site traffic	0.161	Average stay time	0.045
		Average page views	0.116
Website promotion	0.156	Website profile	0.065
		User satisfaction	0.091
Website backstage	0.095	Safety	0.040
		interactivity	0.055
Advertising effect	0.197	Click rate	0.086
		Advertising conversion rate	0.111
Trading results	0.239	Assembly amount	0.129
		Overall profit	0.110

IV. B. 2) Assessment of innovation in real estate transaction models

The expert scoring of qualitative or fuzzy indicators to draw conclusions through the fuzzy comprehensive evaluation method has a wide range of due prospects. There are both qualitative and quantitative indicators in the comprehensive evaluation system of real estate transaction model innovation. The use of this analytical method allows for an effective combination of qualitative and quantitative research for evaluation. In order to assess the innovation level of online transaction mode in the real estate market of the sample region, 10 representative real estate enterprises are selected in the region, the data of each evaluation index are collected, and the fuzzy hierarchical analysis method is applied to measure the collection.The level of innovation of real estate transaction mode in the region from 2015-2024 is shown in Fig. 2.The level of innovation of real estate transaction mode in the region from 2015-2024 overall shows an increasing trend, and the comprehensive evaluation score increases from 0.208 to 0.654.The online transaction mode innovation levels of the 10 real estate enterprises are 0.360, 0.375, 0.375, 0.389, 0.403, 0.420, 0.441, 0.442, 0.488, and 0.458, respectively, and all of them have high real estate transaction mode innovation levels.

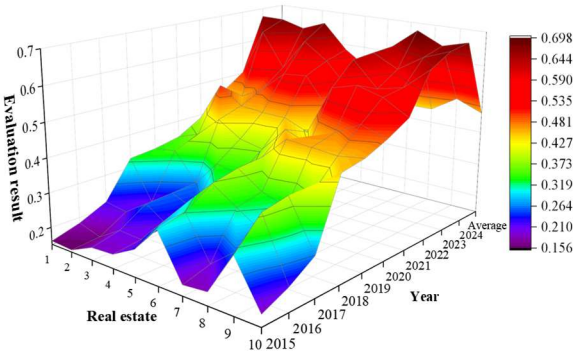

Figure 2: The level of innovation in real estate trading in 2015-2024

IV. C. Multiple regression analysis

IV. C. 1) Selection of variables

Explained variable: e-commerce development level E-c. This paper first establishes a set of indicator system to evaluate the development level of e-commerce and describes its variables in detail, and then, based on the fuzzy hierarchical analysis method and the panel data of 2015-2024, finally arrives at the overall score of e-commerce in a region.

Explanatory variable: the level of real estate transaction model innovation. This study focuses on exploring how e-commerce promotes the improvement of the level of online transaction model innovation in the real estate market, and this level of real estate transaction model innovation includes the general level, the good level and the excellent level.

Control variables: disposable income per capita of residents in a region Income, regional economic development pgdp and industrial structure str. Where regional economic development pgdp is expressed by per capita GDP of each region, and industrial structure str is expressed by the proportion of added value of the tertiary industry to GDP.

The above data come from the Cathay Pacific database, the statistical yearbook of the region, the China Rural Statistical Yearbook and the National Bureau of Statistics.

IV. C. 2) Analysis of empirical results

In order to test the direct effect of e-commerce on the innovation of real estate transaction mode, this paper takes a region as a sample and constructs a benchmark regression model. This paper uses panel data, and after the Hausman test, it is concluded that the P-value is less than 0.1, which rejects its original hypothesis, so it adopts the fixed effect model for regression analysis. Model (1) in Table 3 is the regression analysis of the core explanatory variable real estate transaction model innovation, and models (2)-(4) are the regression analysis of different levels of real estate transaction model innovation level. * represents $p < 0.1$, ** represents $p < 0.05$, and *** represents $p < 0.01$.

Model (1) can be seen that the coefficient of e-commerce development level score on real estate transaction mode innovation is significant at 1% significance level, and the regression coefficient of e-commerce development level score (E-c) is 0.122, which indicates that the level of e-commerce development improves by 1%, the level of innovation of real estate transaction mode improves by 0.122%, so that Hypothesis 1 that e-commerce development can improve the level of real estate transaction model innovation level can be verified.

In terms of control variables, the state of economic development (lnpgdp), per capita disposable income (lninc) and industrial structure (lnstr) have a significant positive impact on the level of innovation in real estate transaction mode, and for every 1% increase, the level of innovation in real estate transaction mode grows by 0.951%, 0.674%, and 0.452%, respectively.

As can be seen from models (2)-(4), the level of e-commerce development as the core explanatory variable passes the significance test for all three real estate transaction model innovation levels. The value of the regression coefficient of the general type is 0.118, the value of the regression coefficient of the good type is 0.116, and the value of the regression coefficient of the excellent type is 0.309, which shows that the rise of e-commerce has brought significant positive effects to all levels of real estate transaction model innovation, confirming the hypothesis 2 that the development of e-commerce has a facilitating role in the innovation of real estate transaction models.

Table 3: The regression results of the fixed effect model

	(1)	(2)	(3)	(4)
	Total	General type	Good type	Excellent type
E-c	0.122***	0.118***	0.116**	0.309***
	0.028	0.062	0.053	0.107
lnpgdp	0.951***	0.947***	0.928***	0.873***
	0.013	0.016	0.022	0.067
lninc	0.674***	0.839***	0.358***	0.596***
	0.071	0.089	0.113	0.041
lnstr	0.452***	0.086	0.947***	0.244
	0.083	0.068	0.085	0.153
_cons	0.193	-0.506**	-0.711**	-3.518***
	0.209	0.232	0.402	0.551
r^2	0.984	0.963	0.958	0.784
r^2_a	0.963	0.952	0.942	0.763

V. Conclusion

The development of e-commerce has had a profound impact on the innovation of online transaction mode in the real estate market. From the results of empirical analysis, there is a significant positive correlation between the development level of e-commerce and the level of real estate transaction mode innovation. Controlling for variables such as economic development, residents' income and industrial structure, every 1% increase in the level of e-commerce development increases the level of real estate transaction mode innovation by 0.122%. This result fully verifies the positive role of e-commerce in promoting online transaction mode innovation in the real estate industry.

The role of e-commerce is also manifested in different levels of transaction model innovation, whether it is general, good or excellent, e-commerce has a significant positive impact on it. In addition, changes in economic development status, residents' income and industrial structure further promote the enhancement of real estate transaction model innovation. Through the multiple influences of these variables, the online transaction model innovation of the real estate market shows an increasing trend year by year during 2015-2024.

These findings suggest that the real estate industry should strengthen the construction of e-commerce, not only to enhance the construction and optimization of online platforms, but also to strengthen the construction of information security to ensure a smooth transaction process. Through innovative online transaction models, the real estate industry can improve market efficiency, reduce transaction costs, and promote the overall development of the industry.

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